Amendments to the Claims

Applicant represents the claims provided in Response A, date of mailing August 21, 2006 to address the concerns of the Notice of Non-Compliant Amendment as follows:

1.[currently amended] An inductive ignition system for an internal combustion engine operating at a voltage Vc substantially above the standard 12 volt automotive battery with one or more ignition coils Ti and associated power switches Swi, where i = 1, 2, ... n, with each coil having a primary winding of turns Np and inductance Lp, and a secondary high voltage winding for producing high voltage sparks of turns Ns and inductance Ls, the primary and secondary winding defining a turns ratio Nt equal to Ns/Np, the coils being of low inductance with one or more large air gaps within their magnetic core, and producing spark of peak current Is above 200 ma, the system further including means for providing the higher voltage Vc and controlling the charging and spark discharging of the ignition coils from said voltage Vc in a controlled sequential manner, and further including connection means for connecting the coil Ti secondary high voltage end to a sparking means which substantially reduces EMI following spark breakdown, the system further including electronic control means for receiving signals to fire the sparking means in their proper order, [~~the main improvement~~] wherein

a) each of the coils having an open-E type magnetic core with the open end located at the high voltage end and not having open ends at the other end of the core as in the case of pencil coils, and wherein two biasing magnets are placed in the open end of the core substantially filling the parallel two open ends or air-gaps, and having relatively higher inductance Lp than the pencil coils with two series gaps, and thus having fewer number of primary turns and satisfying the other features of the invention, i.e. biasing magnetic flux of up to 2 Tesla by use of high flux density biasing magnets;

b) the biasing magnets of each such coil have a length lm essentially filling the air-gap lw or w, the winding window, and cross-sectional area ½ · Abias at right angles to the air-gap direction of the bias magnetic field Bbias, and the direction of the bias magnetic field Bbias is perpendicular to the direction of the magnetic core Bcore of the area ½ · Acore at the intersection of the core and the bias magnets, and

the ends of the center leg and the two side legs of the core which contain the biasing magnets form core leg E-sections which are of essentially uniform cross-section,

c) the biasing magnets have a cross-sectional area ½ · Abias with one side of the two legs of thickness "t" essentially equal to the width or thickness of the core and another side along the length "z" of dimension h approximately equal to or larger than the other dimension of the side leg, i.e. ½ · Abias = t · h, whereby the dimension h is free to be chosen such that the area Abias can be greater than the total core cross-section Acore such that:

(1) the bias magnetic flux density in the entire core can be as high as 2 Tesla with only one pair of bias magnets at one end versus 0.5 Tesla, and

(2) the bias magnetic flux density in the entire core can be as high as 2 Tesla with only one pair of bias magnet at one end versus 1.5 Tesla with two magnets at both ends,

d) the E-core is not a pencil type core but is a solid rectangular core including the biasing magnets at the open end, excluding the winding windows in which the primary winding and secondary winding are contained,

e) and said open-E core with two biasing magnets located at the end of the core substantially resembles a closed E-core commonly found in automotive ignition coils,

[~~of the system being the use of one or more biasing magnets in of said one or more of air gaps in the magnetic core of said low inductance coils to reduce~~] and

whereby there is a reduction of the magnetic core area by approximately 40% for the same coil stored energy, to produce a system that as a whole is more versatile and smaller than prior such systems for the same high coil stored energy.

2. [original claim] The ignition system of claim 1 wherein a micro-controller (MCU) is used for most of the electronic controls that includes generating the charge or dwell time Tch and steering such charging or energizing of the ignition coils in the proper sequence, and firing the spark plugs associated with such coils.

3. [original claim] The ignition system of claim 2 wherein said micro-controller identifies the cylinder to be fired during engine cranking by sensing a voltage from a

few turns of each coil by having all the coils fired simultaneously during cranking, and once identified, to then have the MCU shift to sequential firing with the proper firing order to run the engine.

4. [currently amended] The ignition system of claim 1 wherein the said coils have open-E type magnetic cores at the high voltage end wherein said [~~one or more~~] biasing magnets are located <u>and the core magnetic material is silicon iron</u>.

5. [original claim] The ignition system of claim 4 wherein the magnetic core of said coil is laminated of non-circular cross-section wherein two biasing magnet are used, one each at the core open ends.

6. [canceled] ~~The ignition system of claim 4 wherein the magnetic core of said coil is of circular cross-section and wherein one annular ring type biasing magnet is used at the core open end.~~

7. [original claim] The ignition system of claim 4 wherein said core is contained in a housing with the center core leg in the housing and the outer legs outside of the housing.

8. [original claim] The ignition system of claim 4 wherein between the end of the high voltage winding of said coil and the high voltage connection of the sparking means is included a spiral winding of steel wire wound over a core of magnetic material which has a much higher resistance at and above 1 MHz relative to the DC resistance.

9. [original claim] The ignition system of claim 1 wherein said connection means are spark plug wire with spiral winding of wire of high magnetic permeability over a core including magnetic material which exhibits high loss at 1 MHz or higher frequency relative to DC.

10. [original claim] The ignition system of claim 1 wherein said sparking means are spark plugs with capacitance over 30 pF achieved by electroless chemical dip copper coating of the insulator surfaces.

11. [currently amended] The ignition system of claim [~~10~~] <u>1</u> wherein said insulator is Alumina strengthened with approximately 20% or higher zirconia.

12. [original claim] The ignition system of claim 10 wherein said spark plug has a halo-disc type firing end with recessed or concave high voltage insulator.

13. [previously amended] The ignition system of claim 12 wherein said firing end has a ground ring about the center high voltage electrode wherein said ring is held by four axial supports defining four slots through which air-fuel mixture can flow.

14. [original claim] The ignition system of claim 13 wherein said axial supports define a cone with included angle θ between 30 and 90 degrees.

15. [original claim] The ignition system of claim 10 wherein said spark plug has recessed firing end insulator with large diameter center conductor of diameter approximately 0.15" along the threaded spark plug shell section to provide higher capacitance than normal along this section.

16. [original claim] The ignition system of claim 15 wherein said center conductor is high thermal conductivity material from the collection of copper, brass, and other high conductivity materials.

17. [original claim] The ignition system of claim 1 wherein said switches Swi are IGBTs and wherein their gates are turned on slowly by including high value resistance in series with the gate to substantially reduce the output voltage overshoot upon switch Swi turn-on.

18. [original claim] The ignition system of claim 1 including boost converter for raising said battery voltage Vb to a higher voltage Vc.

19. [original claim] The ignition system of claim 1 wherein said boost converter is by-directional and includes two inductor windings with biasing magnet for the magnetic core.

20. [canceled] ~~An ignition system for an internal combustion engine with more than one ignition coil Ti and associated power switches Swi, where i = 1, 2, ... n, with control means for charging and spark discharging of the ignition coils through sparking means in a controlled sequential manner, the system further including micro-controller (MCU) electronic means for receiving signals to fire the sparking means by having at least one pin Pi associated with each coil Ti , said MCU including A/D converter capability, the MCU means overall being designed to identify the cylinder that is under compression and is to be fired during that ignition firing, called the reference signal, the reference signal being found during the initial engine start up and engine cranking by simultaneously sensing a voltage from a few secondary winding~~

~~turns of at least one coil associated with each engine cylinder, wherein at least one coil per cylinder are simultaneously fired during engine cranking, providing a sense signal to its associated MCU control Pin, which the MCU compares among all the other cylinder pins Pi and finds the maximum or minimum which it identifies that as the reference firing cylinder, from which reference it can then perform proper sequential ignition firing to allow the engine to run properly, without having been provided with a cam or phase signal.~~]

21. [previously presented] The ignition system of claim 1 wherein higher values of winding wire are possible, wherein assuming a primary turns of 60 and secondary turns of 4,200, the primary inductance Lp of 500 uH is easily achievable, and a peak spark current of 350 ma, which is above 200 ma, and a peak primary current of Ip of approximately 25 amps and a coil stored energy of approximately 155 mJ.

22. [currently amended] The ignition system of claim 21 wherein the coil is an open-E coil with the open end at the high voltage end and wherein two biasing magnet are placed at the open ends <u>and wherein the coil resembles a standard ignition coil.</u>

23. [previously presented] The ignition system of claim 22 wherein said biasing magnets have magnetic flux densities of 1 Tesla or higher and the magnetic flux of the coil swings between approximately -1.6 Tesla and approximately +1.6 Tesla to provide a high energy density.

24. [previously presented] The ignition system of claim 23 wherein said switches Swi are 600 volt IGBTs and wherein their gates are turned on slowly by including high value resistance in series with the gate to substantially reduce the output voltage overshoot upon switch Swi turn-on.

25. [currently amended] An inductive ignition system for an internal combustion engine operating at a voltage Vc with one or more ignition coils Ti and associated power switches Swi, where i = 1, 2, ... n, with each coil having a primary winding of turns Np and inductance Lp, and a secondary high voltage winding for producing high voltage sparks of turns Ns and inductance Ls, the primary and secondary winding defining a turns ratio Nt equal to Ns/Np, the coils having an open-E core wherein two large air gaps are contained within the magnetic core, and producing spark of peak current Is above 200 ma because of the large air gaps and lower inductance, and further including connection means for connecting the coil Ti secondary high voltage

end to a sparking means, the system further including electronic control means for receiving signals to fire the sparking means in their proper order,

the system comprising two biasing magnets in said two air gaps in the magnetic core made up of cylindrical laminations comprising a rectangular core producing up to 2 Tesla bias to reduce the magnetic core area by approximately 40% for the same coil stored energy, to produce a system that as a whole is more versatile and smaller than systems for the same high coil stored energy without such feature.

26. [previously presented] The ignition system of claim 25 wherein said biasing magnets have magnetic flux densities of about 1 Tesla or higher and the magnetic flux of the coil swings between approximately -1.6 Tesla and approximately +1.6 Tesla to provide a high energy density.

27. [previously presented] The ignition system of claim 25 wherein the operating voltage Vc is between 24 and 60 volts.

28. [previously presented] The ignition system of claim 25 wherein the two biasing magnets of length lm span the space between the center core and the out core legs at the end of the core, designated as lw, where lm may be equal in length to lw, or slightly less than lw, and wherein the cross-section at right angles to the length lm is approximately equal to the total width of the laminations, and the other cross-sectional dimension, designated as the dimension h for height, is selected to accommodate the primary and secondary bobbins and to give a suitable magnetic flux density for each biasing magnet to produce a suitable average flux in each half of the core.

29. [previously presented] The ignition system of claim 28 wherein the length of the magnetic core lc is approximately 1.6" to approximately 2.0", and the biasing magnets height h is approximately 0.2".

30. [currently amended] An inductive ignition system for an internal combustion engine operating at a voltage Vc with one or more ignition coils Ti and associated power switches Swi, where i = 1, 2, ... n, with each coil having a primary winding of turns Np and inductance Lp, and a secondary high voltage winding for producing high voltage sparks of turns Ns and inductance Ls, the primary and secondary winding defining a turns ratio Nt equal to Ns/Np, the coils having a open-U [~~E~~] core wherein

one [~~two~~] large air gap[s] is [~~are~~] contained within the magnetic core and able to produce spark of peak current Is above 200 ma because of the large air gap[s] and lower inductance, and further including connection means for connecting the coil Ti secondary high voltage end to a sparking means, the system further including electronic control means for receiving signals to fire the sparking means in their proper order,

the system comprising one [~~two~~] biasing magnet[~~s~~] in said [~~two~~] air gap[~~s~~], wherein the biasing magnet[~~s~~] spans essentially the [~~two~~] air gap[s] lw and [~~have~~] has a cross-section approximately equal to the core thickness and a height h much less than the length lc of the magnetic core with minimum biasing greater than 1 Tesla versus 0.5 Tesla, to reduce the required magnetic core area for the same coil stored energy, to produce a system that as a whole is more versatile and smaller than prior such systems for the same high coil stored energy without such features.